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**DUPLICATE**  
 COMPLETE SPECIFICATION.

**Generators of Mixed Gas and Steam and Utilization of such Mixture  
 in Motor Engines.**

I, ROBERT HENRY SMITH, of Ellerslie, Brunswick Road, Sutton, in the County of Surrey, and of 53, Victoria Street, Westminster, in the County of London, Professor of Engineering and Consulting Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to an improved method of and apparatus for the generation of hot high pressure gaseous or vapourous fluid to be used for driving engines of any form either reciprocating or rotative in any of the various manners in which steam or other high pressure vapour air or other gas is used in such engines without combustion in the cylinder or equivalent working chamber.

The object of the invention is to combine certain advantages obtained separately in steam and in internal combustion gas and oil engines and to avoid certain disadvantages inherent in each of these classes of engine.

In gas and oil engines the internal combustion necessitates water-jacket cooling of the working cylinder and thereby involves wasteful rejection of heat at high temperature; the intermittency of the combustion hinders the perfect regulation of the proportion of air to fuel and their perfect intermixture; and the use of only one stroke out of every four or six strokes as a working stroke makes the bulk and weight of the engine excessive in proportion to its horse power. These disadvantages are avoided by the use of my generator as well as by the use of an ordinary boiler and steam engine. On the other hand these latter produce large volumes of highly heated gases which, except for their being dirty and at low pressure, would be usable as working fluid in the cylinder but are discharged to the chimney instead, and it has also been found hitherto impossible to avoid the condensation of a large portion of the steam immediately on its entrance to the cylinder and before it has done any work on the piston. In using my generator the whole of the gases are generated by combustion in a steady and continuous manner under high pressure in a strong vessel apart from the working cylinders, and are afterwards passed through the working cylinders, in which work may be done on every piston stroke. These gases are mixed with the steam evaporated in the same strong vessel and which steam is thus highly superheated and initial cylinder condensation either entirely prevented or greatly reduced according to circumstances. The heat given up by the gases for the evaporation of the water and the superheating of the steam reduces the gas temperature to that degree that is found compatible with easy and durable piston and cylinder working without water-jacket cooling. The temperature attained and the degree of steam superheating depends upon the pressure maintained and upon the proportion of steam generated to each pound of fuel burnt and this proportion is capable of regulation. This proportion depends both upon the area and disposition of the heating surface in contact with water and upon the difference of temperatures between the hot gas on the one side and the water on the other side of this heating surface. The temperature of the water depends upon the pressure maintained and is independent,

[Price 8d.]

*Generators of Gas and Steam and Utilization of such Mixture in Motor Engines.*

or nearly wholly so, of the amount of superheat in the steam, while the temperature of the gas in the furnace depends mainly upon the proportion of air to oil or other fuel injected. For normal working the air injected is to a small extent only in excess of the chemical equivalent required for complete combustion of the fuel, and the area and disposition of the normal heating surface is designed to give the desired degree of superheat with the furnace temperature so arising and with the desired normal pressure. If it be desired to vary the degree of superheat from the normal degree this may be done either by altering the proportion of air to fuel injected or by altering the water level and thus altering the area of the heating surface.

Another advantage of this mode of generating working fluid for engines consists in the equality of the pressures upon the water and furnace sides of the heating surface plates. This equality of pressures permits the use of very thin plates which facilitates the conduction of heat through them and thus increases their heating efficiency per square foot making the size of the generator per horse power smaller. It also permits the use of metals for these plates of high thermal conductivity such as copper or brass without necessitating any increase of thickness as compared with that needed for metals such as steel which has higher tensile strength and lower thermal conductivity. The equality of pressures also makes simpler and cheaper the provision of tightness against leakage of the joints of the heating surface and other plates forming the water space. It also results in very great freedom of the heating surface plates to expand and contract with variation of temperature because these plates need be jointed to the rest of the generator only at the lower end of the water space and may be left entirely unconnected at their upper parts. These advantages form some of the reasons for adopting this design of generator and the attainment of these advantages by means of this design constitutes part of my invention.

In the accompanying drawing Fig. 1 is a sectional elevation of one form of the generator and shows fully its construction. A A is a steel or iron cylinder flanged at its upper and lower ends. B B is a cast steel or iron cover or dome. C is the supply pipe leading the high pressure mixture of gas and steam to the engine. D is a mounting for the attachment of one or two safety valves. E is a mounting for pressure gauge, whistle &c. F is an aperture left open during the warming up of the generator at starting but closed by a screw down valve as soon as the internal pressure begins to be raised.

G G is a thin brass or copper cylindrical partition between the hot gas space H H and the water and steam space which lies between G and A. This brass or copper partition is exposed to equal pressures on both sides. It may therefore be made very thin. This, besides making the weight small and the workmanship inexpensive, gives also high heating surface efficiency. The partition is entirely free from mechanical restraint except at one end and is therefore entirely free to expand and contract with variation of temperature.

K K is a thin brass or copper partition dividing the water space into an outer cooler part containing water alone and an inner hotter part containing water and steam and promoting circulation. L L is the water feed pipe. M M is a baffle plate which as the steam rises from the water space throws it inwards and downwards to mix with the hot gases rising in H H. Upon A A above the level of the top of K K are attached the usual water gauges. Both G G and K K or either of them may be corrugated either longitudinally or circumferentially in order to increase the heating surface efficiency.

N N, the base of the generator, is of cast steel but may be also a steel or iron forging. To it are attached A and G by bolted and rivetted joints. It carries the firebrick combustion chamber lining O O built up in segments and capped by the fire-brick perforated crown P P. Q Q is a fire brick cover to the gun metal burner R R. Q Q burns away rapidly and can be removed and replaced by a fresh cover by drawing the split steel ring on which it rests. The burner contains an outer reservoir for benzoline to be burnt at starting in order to warm up the

*Generators of Gas and Steam and Utilization of such Mixture in Motor Engines*

generator during which time the aperture F is kept open and when also the burner is kept a small distance below its normal position so as to allow the entrance of air round its outer edge to burn the benzoline. The burner is afterwards screwed tight against the conical seat on the lower surface of N N by nuts S S through the intermediation of the bridge beam T T and the block U U. When the nuts are only slightly slackened the block U U can be slung to one side round the hinge pin on which it is set and then the burner as also its firebrick cover Q Q can be dropped below the lower edge of N N and withdrawn sidewise.

Pipe supplies of high pressure air and petroleum or other oil fuel or gaseous fuel are brought into the bridge T T. These are led by annular passages through U and the lower part of the burner up to the combustion nozzle where the air and oil jets are made to impinge on each other and upon gunmetal baffle surfaces.

The drawing shows a small sized generator, A A being 16 inches in diameter by 4 ft. length. In large sizes the dome and base plate B B and N N are not cast but are boiler plate structures.

The air is supplied from a high pressure reservoir fed by one or more air pumps. The air is filtered on its way to the suction valves of the pump. Such filtering is unnecessary if gaseous fuel be used unless the air be unusually dirty and it is useless if solid powdered fuel be used. In the latter case the mixture of gas and steam should be filtered of ash dust on its way from the generator to the engine.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is:—

(1) The burning of fuel, preferably oil but also gaseous and finely powdered solid fuel, in a steady and continuous manner under high pressure in one part of a strong vessel which contains water in another part.

(2) The evaporation of the water by conduction of the heat of the products of combustion through a metal partition which has equal pressures on either side, which can therefore be made very thin, and which therefore has high efficiency as a heating surface.

(3) The superheating of the steam and the cooling of the gaseous products of combustion down to the temperature of the superheated steam by the actual intermixture of the steam and the hot gases.

(4) The use of such mixture of steam and hot gas as the working fluid in any form of engine not an internal combustion engine.

(5) The adjustment of the proportion of steam produced to fuel burned so as to superheat the steam sufficiently to prevent entirely or for the most part initial condensation and so as to cool the gas sufficiently to prevent burning of the cylinder and piston surfaces without water-jacket cooling and to permit easy efficient lubrication of the piston motion.

(6) The combination of the parts of the generator to effect the operations mentioned in Claims 1, 2, 3, and 5 substantially as hereinbefore described and illustrated.

Dated this 10th day of March 1898.

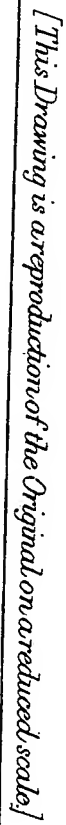
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SMITH'S COMPLETE SPECIFICATION.

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